Rapid growth of caves and speleothems: part 1—the excavation of the cave

Michael J. Oard

Caves and their decorations, speleothems, are commonly thought to have formed slowly over millions of years. However, secular scientists struggle to explain how caves could have been excavated by the weak carbonic acid formed in surface soil. Moreover, speleothems are dated too young to fit within their paradigm, and drip locations cannot remain in one place long enough to build any huge speleothems. However, recent research suggests that caves can be excavated rapidly by sulfuric acid dissolution. This is consistent with caves being carved from the widespread occurrence of sulfuric acid from plant and animal decay, and by continental uplift during the Recessive Stage of the Flood.

Caves are beautiful but eerie. They display almost an infinite variety of forms, called speleothems, including stalactites (figure 1) and stalagmites (figure 2). Sometimes stalactites and stalagmites join to form a column (figure 3), which can be massive and display fanciful shapes. Speleothems also include flowstones, sheets of carbonate deposits formed along the walls or floors of caves (figure 4).

In three consecutive papers we will examine differing aspects of caves. First, we will show how the Genesis Flood provides a better framework for explaining how caves were first excavated (part 1). Then we will delve into the growth rate variables of caves and speleothems (part 2).[1] Finally (part 3),[2] we will show that indeed speleothems can form rapidly under the unique conditions that prevailed during the Ice Age.

Caves believed to take millions of years to form

Uniformitarian scientists point to numerous geological processes that are assumed to change so slowly that it would take tens of thousands to millions of years of geological time to create geological features. Caves are one such geological feature. If we assume the present is the key to the past, caves appear to require hundreds of thousands to millions of years to form because most speleothems grow very slowly today. For instance, cave experts Carol Hill and Paolo Forti often hear cavers and cave visitors alike declare: "A large stalactite or stalagmite takes millions of years to form."[3] Moreover, anti-creationist geologist Arthur Strahler challenged creation scientists on the origin of caves:

> "If it can be shown that either the excavation of caverns or their subsequent filling must require a vastly longer time to accomplish than the post-Flood limit, literal acceptance of the Genesis chronology is untenable. We turn first to rates of removal of limestone by the process of carbonic-acid reaction."[4]

This quote illustrates that Strahler believes that carbonic acid dissolves carbonate to form the cave opening. However, this is an outdated idea that is based on strict uniformitarianism, since carbonic acid is the only acid that forms in significant quantities in groundwater today. Carbonic acid must therefore seep down from the soil through carbonate and other rocks to reach the area where the acidic water is said to dissolve them.

Surprisingly, modern textbooks still teach that caves form by carbonic acid dissolution[5] despite the research by Hill and Forti that these beliefs are untrue, and that caves take "more likely, only tens to hundreds of thousands of years".[6]

Contrary uniformitarian aspects of caves

Caves have simply been assumed to have formed by carbonic acid dissolution because that is what is observed today. However, some scientists admit that no mechanism for cave excavation by carbonic acid is known: "Ground water forms caves, but exactly how is not known."[7] In fact, a close examination into the details of cave formation reveals that several aspects of caves actually contradict a uniformitarian explanation.

Problem of how caves excavated by carbonic acid

Carbonic acid is commonly formed in the soil and as it seeps through cracks in the carbonate, it quickly reacts with the carbonate, dissolving it and *neutralizing* the acid. Thus, the percolating water loses most of its ability to dissolve increasing amounts of carbonate that it encounters. This occurs within about 10 m of the surface.[8] Some say within one metre.[9] If so, though, how could percolating carbonic acid continue to seep downward, sometimes over 1,000 m, and remain acidic enough to dissolve even wide cave passageways? This conundrum is why researchers

believe cave development is confined to shallow depths: "The classic model for karst development (speleogenesis) is carbonic acid dissolution of carbonate rocks, usually at shallow depths rarely below the water table."[10]

Karst[11] is mainly rough limestone country with underground drainage (figure 5). However, many caves in karst landscapes were formed quite deep—well away from the carbonic acid near the surface, especially considering the large amount of Cenozoic surface erosion (see below for the caves in the Guadalupe Mountains, New Mexico, USA). Uniformitarian scientists say that since such caves exist, the acidic water must have penetrated quite deep. As a result, several *ad hoc* mechanisms have been devised in an attempt to account for this paradox in their speleogenesis models.[9] For instance, some have proposed that when two calcium-saturated solutions mix, the mixture can become unsaturated and dissolve more of the wall of a crack.[12] However, Dreybrodt subsequently admitted that such mixtures become quickly saturated.[13] Such a mechanism does not seem too significant. Deep time is commonly added with the implications that cracks will widen given enough time. However, the time for cracks to widen so that turbulent flow can be initiated may be too long to solve the paradox. Caves require faults and joints, but these are known to fill with minerals and become impermeable to water.[14] Moreover, uniformitarian 'thinking' needs a deep valley to make the groundwater move toward the potential cave. Without the deep valley, the water does not move at all or moves too slowly to be effective.[15]

Speleothems too young

Show caves, those which the public is allowed to access, commonly display stalagmite growth rates of 0.1 to 3 mm/yr,[8] which are typical for the present day. At this slow current rate

Figure 1. Stalactites from Luray Caverns, Virginia, USA, with their reflection in a pool

Figure 2. Stalagmites in foreground with stalactites and columns in the background from Luray Caverns, Virginia, USA

Figure 3. Wide column from Luray Caverns, Virginia, USA

a 2-m-high stalagmite would take 700 to 20,000 years to form. These rates are still much faster than the results of radiometric dating commonly indicate, which is why Hill and Forti now believe extremely few speleothems are millions of years old, but are instead tens to hundreds of thousands of years old.[6] Under the conditions described in Scripture, a global Flood and the following Ice Age would have caused speleothems to grow much faster than the ages derived from the dating methods. Cave geologist, Dr Emil Silvestru, drives home the conclusion:

> "Now, let's consider one of the tallest stalagmites in the world, in the cave Armand (France)—shown above. At 3 mm per year it would have reached its present 38 m in 12,700 years. Clearly, this contradicts the ages of hundreds of thousands of years obtained from radiometric dating! But, on the surface, it would appear to be too old for the Flood. … However, as I looked closely at this stalagmite, I realized that its growth must have been even faster in the past, because the water falls over 90 m (300 ft) from the roof to the tip of the stalagmite. This drop, plus the powerful splash at the end, would make it lose CO_2 faster. Furthermore, the climate in the area used to be much wetter about a millennium ago, which would have accelerated growth even more. … Returning to our generic example: if a 2 m stalagmite were 200,000 years old, its annual growth rate must have averaged 0.01 mm per year. This is ten times slower than the slowest measured today! Long-agers try to explain this by saying that the growth occasionally stopped completely, perhaps for 10,000 years at a time. And after 10,000 years, they assume that nothing changed—the water drops start arriving again at exactly the same point, with millimetre precision, to fall on the tip of the stalagmite!"[16]

The explanation of a starting and stopping of the drip rate Silvestru notes is very likely a *rescuing device with little to no evidence.* So, secular scientists have a time problem: their dating methods make the speleothems much too old for today's growth rates.

Other uniformitarian scientists have also come to realize that caves are not that old. Some claim they are less than 5 Ma old, formed in Pliocene to Pleistocene time.[17] Carlsbad Cavern (figure 6) is considered to be about 4 Ma old,[18]

Figure 4. Flowstone (left) from Luray Caverns, Virginia, USA

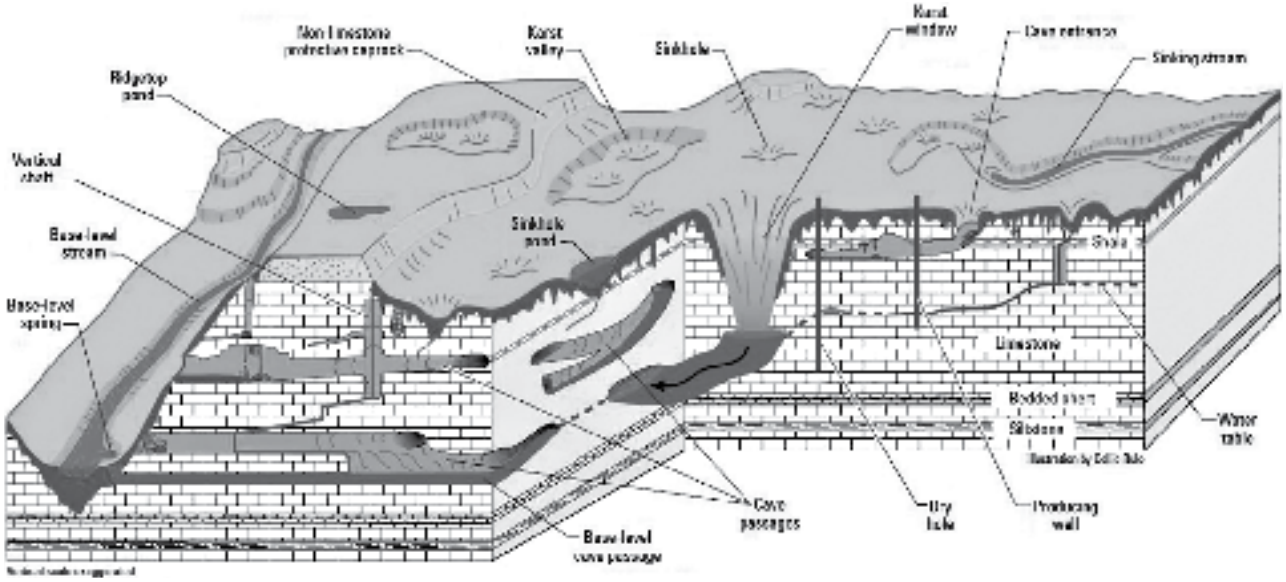

Figure 5. Physiographic and hydrologic features typical of a well-developed karst terrane (USGS)

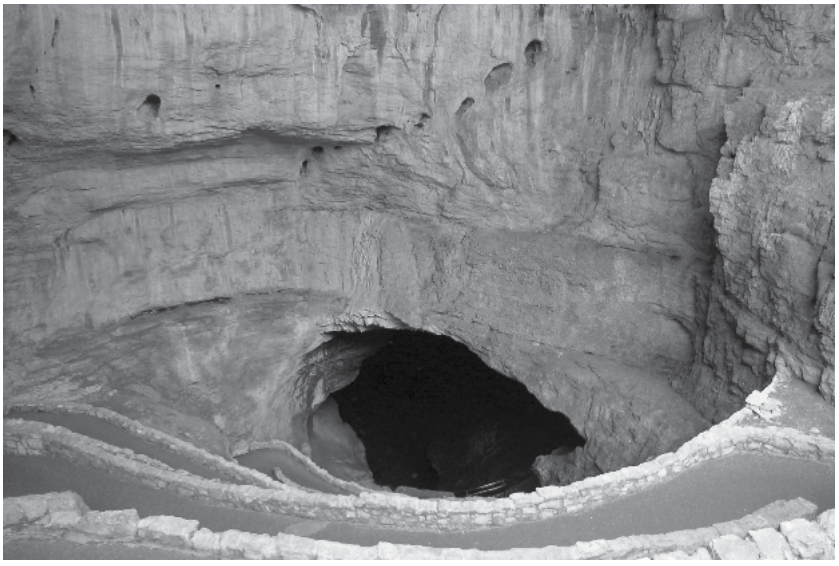

Figure 6. Entrance to Carlsbad Cavern, New Mexico, USA

although the limestone itself is said to be about 250 Ma old. Why not consider the possibility that the caves formed before the Pliocene? After all, the landscape is usually believed to have been around much longer than the Pliocene.

Researchers use uranium series dating for most speleothems, especially if they are confident they are beyond the range of carbon-14 dating (c. 50,000 years). A few other dating methods are also applied, especially beyond 500,000 years, the maximum range for the uranium series method. Regardless, very few claim any speleothem is older than 500,000 years. Secular scientists claim that we need to take into consideration speleothem 'erosion'. In other words, speleothems break off and stop growth, possibly by a cave flood that shears off their base. They use this to explain why they give such a young age.

Drip locations do not remain stationary for long periods

There is a problem inherent with stalactites as young as hundreds of thousands of years old. Their age would imply that the water path through the vegetation and soil above the cave, down through the soil, and through the carbonate[1,19] did not change in all that time. But the soil and vegetation above a cave changes on a regular basis. Moreover, the water path above the caves constantly changes, with variable drip rates at all sites.[20] It is rare for a speleothem to have a steady drip year after year. And in an ever-changing climate and soil environment, each stalagmite responds differently.[21] The drip point for a particular stalagmite should be constantly shifting to new locations, as observed today. Silvestru elegantly states the problem:

> "Evolutionists claim speleothems formed over hundreds of thousands of years. But in my own evolutionary days, I had never considered an important consequence of such an age: the tiny water droplet, which built that stalagmite, had to keep arriving at precisely the same spot on the floor of the cave for 100,000 years! … Well, I knew—and all karstologists know—that the surface of limestone terrains above caves changes dramatically in short periods of time. And any change at the surface also changes the location of the water droplets inside the cave. However, the stalagmites do not indicate any changes. So, the conclusion is simple: they cannot be that old. And that fact indicates the old-age belief is fallacious."[22]

The Flood origin of the cave openings

Before spectacular speleothems are formed, we need a cave. Caves are almost entirely formed in carbonates, but there are a few formed in 'evaporites' and even in sandstone. An evaporite is a chemical sedimentary rock believed to have formed from evaporation, such as salt or gypsum.[23]

Caves first, speleothems second

It appears that cave openings formed first. When the dissolution of the cave stopped, the process was reversed and carbonates (speleothems) were deposited inside the caves.[24] If both dissolution and deposition occurred at the same time, there should be a chaotic mixture of features that record ongoing periods of dissolution and deposition. These do not exist. Uniformitarian scientists have great difficulty figuring out how carbonic acid formed near the surface, percolated down, and still maintained enough acidity to dissolve cave openings along joints, faults, and weak bedding planes. They say creationists have a worse problem—time. But whilst the biblical timescale allows only a little more than 6,000 years[25] the Flood and Ice Age provided unique conditions that would facilitate rapid cave formation. Cave openings would have formed rapidly during the Flood and a little afterwards, and the speleothems formed during the rapid, post-Flood Ice Age.[26,27]

Caves excavated by sulfuric acid

A recent discovery made by uniformitarian scientists provides a more viable process for cave formation than carbonic acid. It was first hypothesized in the 1970s that caves could be excavated by sulfuric acid, possibly aided

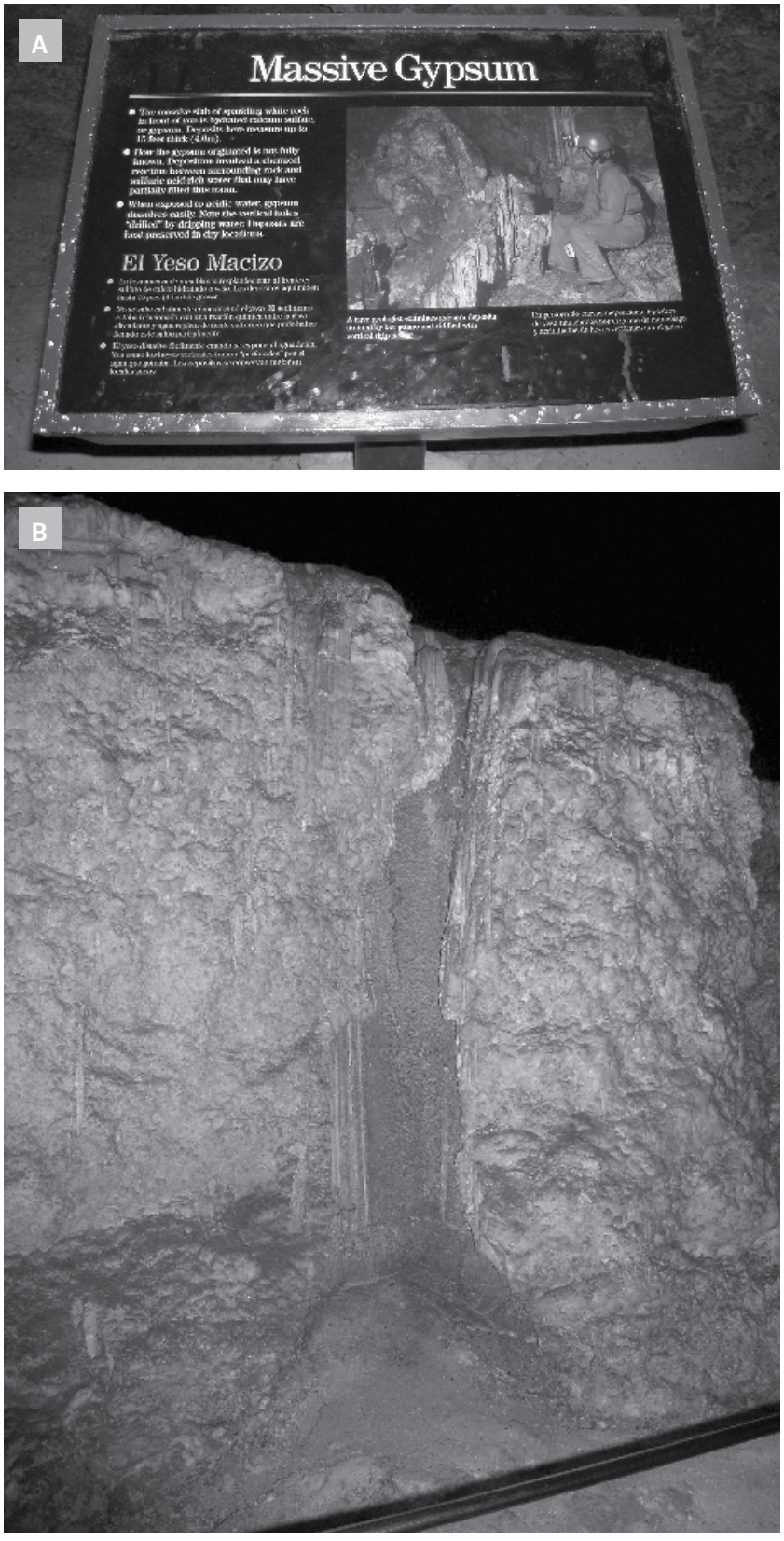

Figure 7. A) Sign in front of a massive gypsum deposit, Carlsbad Cavern, New Mexico, USA; B) Massive gypsum, Carlsbad Cavern, New Mexico, USA.

by microbes.[28] Then, based on certain cave minerals such as elemental sulfur, gypsum, halloysite, and alunite, sulfuric acid speleogenesis was recognized in other areas of the world, especially Carlsbad Caverns and other caves of the Guadalupe Mountains of south-east New Mexico.[18,29,30–32] These are called *hypogene caves* as opposed to those supposedly formed by carbonic acid, which are called epigene caves. The Guadalupe Mountains caves were formed in what has been considered a classical ancient reef, the 'Capitan Reef', which supposedly formed during the 'Permian' over 250 Ma. However, some geologists consider it unlikely to be a true reef: "The massive block is usually called a 'reef', but it shows few characteristics of a true reef."[33]

Gypsum is a product of sulfuric acid dissolution of carbonate. It is abundant in Carlsbad Caverns, where it can be over 4 m (13 ft) thick on the floor of the Big Room (figures 7a and 7b). It is believed H_2S from nearby oil deposits to the south-east formed the sulfuric acid that dissolved the limestone at Carlsbad Caverns and nearby caves. This is uncertain, since it is not observed occurring today. All researchers know is that the $\delta^{34}S$ value of the gypsum indicates that the sulfur products are biogenic. Alunite apparently can be dated by the $^{40}Ar/^{39}Ar$ dating technique, which provided the incentive for geologists to investigate the above reaction products.[18]

In light of this direct evidence for sulfuric acid dissolution, it was once claimed that 10% of caves worldwide were formed by sulfuric acid dissolution.[34] The other 90% of caves were explained by the dissolution by carbonic acid.[34] However, cave scientists are discovering more and more caves were excavated by sulfuric acid. In the preface of a 2017 book on the topic of hypogenic caves, the editors state:

> "More attention to hypogene karst since 1990, and particularly

> the dramatic burst of studies in this field during the last decade, has changed our notion of hypogene karst from a curiosity to one of the fundamental categories of karst, at least of compatible importance with more familiar epigene karst. … Hence, the potential for the development of hypogene karst is immense, not only in the continental domain but also in the oceanic domain. … Moreover, even in Europe and North America, many areas have been recognized only recently to host hypogene karst, and its study is still ongoing. This means that next editions or volumes under this title will be needed."[35]

The editors believe that the hypogene caves were formed by ascending hydrothermal water and that caves can form up to 2 km deep. The book is over 700 pages long and describes a large number of hypogenic caves all over the world. There are now so many hypogene caves that cave expert Klimchouk states that "this phenomenon can be globally even *more* widespread than epigene karst [emphasis added]."[36] Twenty-five percent of hypogene caves are found in Italy.[37] This means that it is likely that more than 50% of caves are hypogenic. It could be 100% of caves are hypogenic, especially since it is difficult to tell epigenic from hypogenic caves.[38] They also believe that hypogene caves are mostly relic, not forming today, and that they formed deep down and were brought to the surface by uplift and erosion.[39]

Rapid sulfuric acid dissolution during Flood uplift

This new information opens up the distinct possibility that many cave openings were excavated rapidly during the Flood by sulfuric acid. However, there could be other powerful acids also available in hydrothermal water,[40] that could excavate cave openings rapidly. Sulfuric acid formed from the oxidation of hydrogen sulfide (H_2S) in water would have dissolved the cave opening in a short time.[32,41] The H_2S would come from decaying organic matter (as also indicated by the biological signature of $\delta^{34}S$) which would be highly concentrated in the sediments after the Flood due to the burial and pulverization of the rich pre-Flood biosphere.[42] The acids need not ascend as believed for the Guadalupe Mountains caves, but likely descended during Flood uplift of the area. Evidence for high-speed flow of acidic water is shown by the large amounts of gravel, cobbles, and boulders, not of carbonate, that are found in many caves.[40] The caves used to be *underground rivers*. Once an opening is fairly wide, turbulent flow would occur. This would excavate carbonates many times faster than in laminar flow[43] because the retarding kinetic effects due to a boundary layer are mostly erased in turbulent flow.[1] The cave openings would then be rapidly enlarged by dissolution. The purity of gypsum in Carlsbad Cavern is one indication of rapid excavation and deposition.[29]

Sulfuric acidic excavation of cave openings is likely best placed within the middle and late Flood, and possibly a little afterwards (figure 8). First, thick, extensive carbonates were laid down and solidified during the Inundatory Stage of the Flood (figures 8a and 8b).[44] Since carbonates have their own cement (calcite), they would likely have solidified rapidly. Second, during the Recessional Stage there was widespread uplift, which was also a massive erosional event on the surface of the continents (figures 8c and 8d).[45,46] The carbonates would have easily cracked, forming joints and faults, since uplift causes expansion and differential movement of rock. This cracking would have extended deep within the carbonates.

Since the sediments and sedimentary rocks freshly laid down in the Flood would have been fluid-rich and likely hot, the chemical-rich water from the Flood would have raced through the joints, faults, and weaknesses in the bedding planes, rapidly dissolving the limestone and creating caves (figure 8c). Numerous caves form rectangular mazes guided by joint and fault patterns and bedding plane weaknesses, reflecting this pattern expected from the Flood and its immediate aftermath.[47]

The Guadalupe Mountains, a dissected planation surface, show evidence of such a timing.[48] J. Harlen Bretz, of Lake Missoula flood fame,[49,50] has shown that the caves were excavated *before* the area was planed. Valleys and canyons cut through caves, and some caves are in relatively narrow ridges and could not form from any soil at the top of the ridge.[51] The caves also do not conform to the topography.[52] This strongly suggests that the caves were excavated near the beginning of uplift, possibly in the Zenthitic Phase in Walker's biblical geological model.[44] Excavation was so rapid that the caves were already formed before the end of the planing event of the Abative Phase.[45,53]

Even if the dissolution products of sulfuric acid are not found in some caves, they could quite easily have been washed out during Flood drainage. It makes sense that gypsum and other products of sulfuric acid reactions would wash out of the cave, since the Flood water draining through the cave networks would be much more substantial than the water draining out at present. It is also possible that present processes have obscured or covered up the evidence for sulfuric acid speleogenesis.[54] Moreover, the sheer dominance of the carbonic acid paradigm in cave research contributes to the slow acceptance of a more widespread hypogenetic origin for caves.[55] Silvestru states in regard to the Jenolan Caves in Australia:

> "Though recently hailed as the world's oldest (340 Ma) open cave system, the Jenolan Caves system can be explained as the result of hydrothermal karsting during the final stages of the Noahic Flood, subsequently reshaped and disorganized by meteoric speleogenesis and surface erosion."[56]

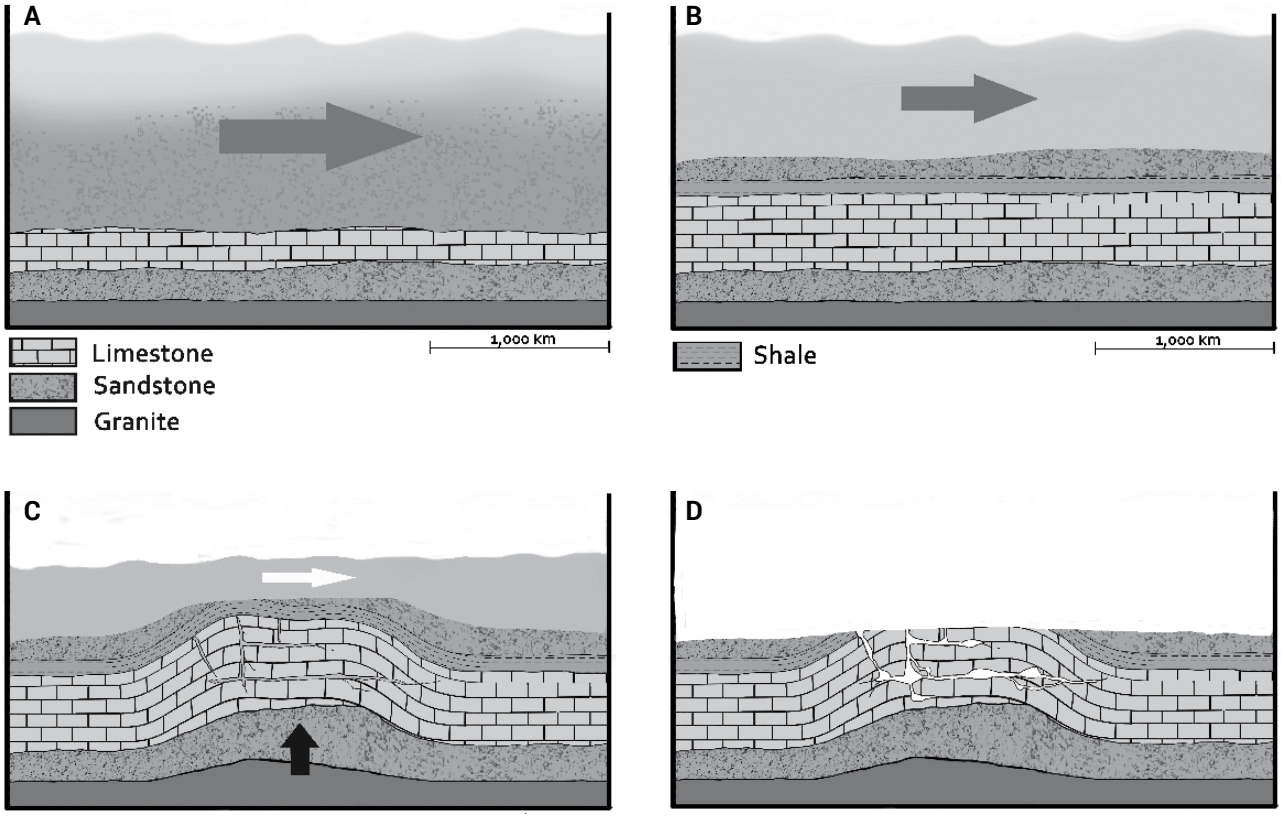

Figure 8. Schematic of the deposition of carbonates during the Flood (A and B) followed by the Recessional Stage uplift and cracking of the carbonate (C), forming caves by rapid sulfuric acid dissolution (C and D) (by Melanie Richard).

Summary

Uniformitarianism has several problems explaining caves and their speleothems. First, the idea of cave openings dissolved by carbonic acid from the surface is problematic. Carbonic acid is neutralized quickly as it sinks through the cracks in the vadose zone. Second, although secular scientists claim the entire process took millions of years, the youth of speleothems contradicts this idea. Third, large speleothems imply long-lasting dripping at one location, but because of the changes in water routing, the drips would change location frequently, making it nearly impossible to build up a large speleothem.

A paradigm shift is taking place on the origin of cave openings. Scientists have discovered that many caves, possibly most of them now, have been excavated by sulfuric acid because the products of the carbonate dissolution have been left in the cave. This fits well with the biblical paradigm. The cave openings could have been rapidly excavated during uplift in the Recessional Stage of the Flood.

In part 2,[1] we will shift from the excavation of the cave openings to the conditions needed to form the speleothems, while in part 3[2] we will show that the unique features of the post-Flood Ice Age can account for the growth of the main volume of the speleothems.

References

1. Oard, M.J., Rapid growth of caves and speleothems: part 2—Growth rate variables, *J. Creation*, in press.
2. Oard, M.J., Rapid growth of caves and speleothems: part 3—Flood and Ice Age variables, *J. Creation*, in press.
3. Hill, C. and Forti, P., *Cave Minerals of the World*, 2nd edn, National Speleological Society, Huntsville, AL, p. 285, 1997.
4. Strahler, A.N., *Science and Earth History—The evolution/creation controversy*, Prometheus Books, Buffalo, NY, p. 280, 1987.
5. Plummer, C.C. and McGeary, D., *Physical Geology*, 7th edn, William C. Brown Publishers, Dubuque, IA, pp. 243–245, 1996.
6. Hill and Forti, ref. 3, p. 287.
7. Foster, R.J., *General Geology*, Charles E. Merrill Publishing Company, Columbus, OH, p. 268, 1969.
8. Silvestru, E., Caves for all seasons, *Creation* **25**(3):44–49, 2003.
9. Szymczak P. and Ladd, A.J.C., The initial states of cave formation: beyond the one-dimensional paradigm, *Earth and Planetary Science Letters* **301**:424–432, 2011.
10. Engel, A.S., Stern, L.A., and Bennett, P.C., Microbial contributions to cave formation: new insights into sulfuric acid speleogenesis, *Geology* **32**(5):369, 2004.
11. Karst is: "A type of topography that is formed on limestone, gypsum, and other soluble rocks, primarily by dissolution. It is characterized by sinkholes, caves, and underground drainage." Neuendorf, K.K., Mehl, Jr., J.P., and Jackson, J.A., *Glossary of Geology*, 5th edn, American Geological Institute, Alexandria, VA, p. 348, 2005.
12. Dreybrodt, W., Kinetics of the dissolution of calcite and its applications to karstification, *Chemical Geology* **31**:245–269, 1981.
13. Dreybrodt, W., The role of dissolution kinetics in the development of karst aquifers in limestone: a model simulation of karst evolution, *J. Geology* **98**:639–655, 1990.

14. Dreybrodt, W., *Processes in Karst Systems: Physics, chemistry, and geology*, Springer-Verlag, New York, p. 190, 1988.
15. Dreybrodt, ref. 14, p. 236.
16. Silvestru, ref. 8, pp. 48–49.
17. Panno, S.V. and Bourcier, W.L., Glaciation and saline-freshwater mixing as a possible cause of cave formation in the eastern midcontinent region of the United States: a conceptual model, *Geology* **18**:769–772, 1990.
18. Polyak, V.J., McIntosh, W.C., Güven, N., and Provencio, P., Age and origin of Carlsbad Cavern and related caves from $^{40}Ar/^{39}Ar$ of alunite, *Science* **279**:1919–1922, 1998.
19. Practically all caves occur in limestone. I will not deal with those that occur in dolostone or gypsum, or the isolated instances of sandstone caves, such as the caves in the Proterozoic Roriama Formation of north-west South America.
20. Baker, A. and Brunsdon, C., Non-linearities in drip water hydrology: an example from Stump Cross Caverns, Yorkshire, *J. Hydrology* **277**:151–163, 2003.
21. Genty, D., Baker, A., and Vokal, B., Intra- and inter-annual growth rate of modern stalagmites, *Chemical Geology* **176**:191–212, 2001.
22. Silvestru, E., Caves: how radioactive dating confuses the situation and age, *Creation* **34**(1):46, 2012.
23. Neuendorf, K.K., Mehl, Jr., J.P., and Jackson, J.A., *Glossary of Geology*, 5th edn, American Geological Institute, Alexandria, VA, p. 221, 2005.
24. It is likely that slow carbonate dissolution continues in some caves based on the calcium ions leaving the cave in the groundwater (see Austin, ref. 40), but the calcium ions could be from drip water that has not deposited all its calcium on the speleothems or from underground streams passing through the cave with dissolved calcium.
25. Oard, M.J., *The Deep Time Deception: Examining the case for millions of years*, Creation Book Publishers, Powder Springs, GA, 2019.
26. Oard, M.J., *Frozen in Time: Woolly mammoths, the ice age, and the biblical key to their secrets*, Master Books, Green Forest, AR, 2004.
27. Oard, M.J., *The Great Ice Age: Evidence from the Flood for its quick formation and melting*, Awesome Science Media, Canby, OR, 2013.
28. Engel *et al.*, ref. 10, pp. 369–372.
29. Hill, C.A., Geology of Carlsbad Cavern and Other Caves in the Guadalupe Mountains, New Mexico and Texas, *New Mexico Bureau of Mines and Mineral Resources Bulletin 117*, New Mexico Institute of Mining and Technology, Socorro, NM, 1987.
30. Hill, C.A., Sulfuric acid speleogenesis of Carlsbad Cavern and its relationship to hydrocarbons, Delaware Basin, New Mexico and Texas, *The American Associations of Petroleum Geologists Bulletin* **74**(11):1685–1694, 1990.
31. Sasowsky, I.D., Determining the age of what is not there, *Science* **279**:1874, 1998.
32. Oard, M.J., Rapid cave formation by sulfuric acid dissolution, *J. Creation* **12**(3):279–280, 1998; creation.com/images/pdfs/tj/j12_3/j12_3_279-280.pdf.
33. DuChene, H.R., Palmer, A.N., Palmer, M.V., Queen, J.M., Polyak, V.J., Decker, D.D., Hill, C.A., Spilde, M., Burger, P.A., Kirkland, D.W., and Boston, M.P., Hypogene speleogenesis in the Guadalupe Mountains, New Mexico and Texas, USA; in: Klimchouk, A., Palmer, A.N., Waele, J.D., Auler, A.S., and Audra, P. (Eds.), *Hypogene Karst Regions and Caves of the World*, Springer, AG, p. 512, 2017.
34. Palmer, A.N., Origin and morphology of limestone caves, *GSA Bulletin* **103**:1–21, 1991.
35. Klimchouk, A., Palmer, A.N., Waele, J.D., Auler, A.S., and Audra, P.; in: Klimchouk, A., Palmer, A.N., Waele, J.D., Auler, A.S., and Audra, P. (Eds.), *Hypogene Karst Regions and Caves of the World*, Springer, AG, pp. v, vi, 2017.
36. Klimchouk, A., Types and settings of hypogene karst; in: Klimchouk, A., Palmer, A.N., Waele, J.D., Auler, A.S., and Audra, P. (Eds.), *Hypogene Karst Regions and Caves of the World*, Springer, AG, p. 32, 2017.
37. D'Angeli, I.M., Carbone, C., Nagostinis, M., Parise, M., Vattano, M., Madonia, G., and Waele, J.D., New insights on secondary minerals from Italian sulfuric acid caves, *International J. Speleology* **47**(3):271–291, 2018.
38. Palmer, A.N., Distinction between epigenic and hypogenic maze caves, *Geomorphology* **134**:9–22, 2011.
39. Klimchouk, ref. 36, p. 34.
40. Austin, A.A., Origin of limestone caves, *Acts & Facts Impact No. 79*, Institute for Creation Research, Dallas, TX, 1980.
41. Silvestru, E., *Wonders of Creation: The cave book*, Master Books, Green Forest, AR, pp. 65–67, 2008.
42. Silvestru, E., A hydrothermal model of rapid post-Flood karsting; in: Ivey, Jr., R.L. (Ed.), *Proceedings of the Fifth International Conference on Creationism*, technical symposium sessions, Creation Science Fellowship, Pittsburgh, PA, pp. 233–241, 2003.
43. Buhmann, D. and Dreybrodt, W., The kinetics of calcite dissolution and precipitation in geologically relevant situations of karst areas: 2. Closed system, *Chemical Geology* **53**:109–124, 1985.
44. Walker, T., A biblical geological model; in: Walsh, R.E. (Ed.), *Proceedings of the Third International Conference on Creationism*, technical symposium sessions, Creation Science Fellowship, Pittsburgh, PA, pp. 581–592, 1994; biblicalgeology.net/.
45. Oard, M.J., *Flood by Design: Receding water shapes the earth's surface*, Master Books, Green Forest, AR, 2008.
46. Oard, M.J. (ebook), *Earth's Surface Shaped by Genesis Flood Runoff*, 2013, Michael.oards.net/GenesisFloodRunoff.htm.
47. Ford, D.C. and Williams, P.W., *Karst Geomorphology and Hydrology*, Unwin Hyman, London, p. 37, 1989.
48. Horberg, L., Geomorphic history of the Carlsbad Caverns area, New Mexico, *J. Geology* **57**(5):464–476, 1949.
49. Oard, M.J., *The Missoula Flood Controversy and the Genesis Flood*, Creation Research Society Books, Chino Valley, AZ, 2004.
50. Oard, M.J., *The Great Missoula Flood: Modern day evidence for the worldwide Flood*, Awesome Science Media, Richfield, WA, 2014.
51. Bretz, J.H., Carlsbad Caverns and other caves of the Guadalupe block, New Mexico, *J. Geology* **57**(5):447–463, 1949.
52. DuChene *et al.*, ref. 33, pp. 511–530.
53. Oard, M.J. (ebook) *Earth's Surface Shaped by Genesis Flood Runoff*, 2013 Michael.oards.net/GenesisFloodRunoff.htm.
54. Waele, J.D., Forti, P., and Naseddu, A., Speleogenesis of an exhumed hydrothermal sulphuric acid karst in Cambrian carbonates (Mount San Giovanni, Sardinia), *Earth Surface Processes and Landforms* **38**:1369–1379, 2013.
55. Kimchouk, A., Morphogenesis of hypogenic caves, *Geomorphology* **106**:100–117, 2009.
56. Silvestru, E., The age of the Jenolan Caves, Australia, *J. Creation* **21**(1):96–97, 2007.

Michael J. Oard *has an M.S. in atmospheric science from the University of Washington and is now retired after working as a meteorologist with the US National Weather Service in Montana for 30 years. He is the author of* Frozen in Time, Ancient Ice Ages or Gigantic Submarine Landslides?, Flood by Design, Dinosaur Challenges and Mysteries, *and* Exploring Geology with Mr. Hibb. *He serves on the board of the Creation Research Society.*